



**Research Report
KTC-96-23**

Rubberized Asphalt Membrane

by

Kamyar C. Mahboub, Ph.D., P.E.
Associate Professor of Civil Engineering

Kentucky Transportation Center
College of Engineering
University of Kentucky

in cooperation with
Kentucky Transportation Cabinet

and

Federal Highway Administration
U.S. Department of Transportation

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the University of Kentucky, the Kentucky Transportation Cabinet, nor of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. The inclusion of manufacturer names or trade names are not to be considered as endorsements.

September 1996

1. Report No. KTC-96-23		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Rubberized Asphalt Membrane				5. Report Date September 1996	
				6. Performing Organization Code KTC-96-23	
7. Author(s) K. C. Mahboub				8. Performing Organization Report No.	
9. Performing Organization Name and Address KENTUCKY TRANSPORTATION CENTER COLLEGE OF ENGINEERING UNIVERSITY OF KENTUCKY				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
				13. Type of Report and Period Covered Final	
12. Sponsoring Agency Name and Address Kentucky Transportation Cabinet State Office Building				14. Sponsoring Agency Code	
15. Supplementary Notes Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration					
16. Abstract This document reports findings of a study involving the use of scrap tire chips in an asphaltic membrane. The research project was designed with two objectives in mind. First, to investigate the effectiveness of an asphaltic membrane on top of a subgrade for maintaining moisture equilibrium in subgrade, and second, to study the potential use of scrap tire chips in asphaltic membranes. The effectiveness of the membrane as a moisture barrier needs to be evaluated over a long period of time (i.e. several years). However, the method proved to be a feasible alternative for recycling waste tires in pavements. It is hoped that this study will contribute to various efforts in the area of cost effective and sound utilization of waste materials in construction.					
17. Key Words Asphalt Pavement Subgrade Tire Rubber Pavement Membrane				18. Distribution Statement Unlimited with approval of Federal Highway Administration, and Kentucky Transportation Cabinet	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 21	
				22. Price	

SI (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				APPROXIMATE CONVERSIONS FROM SI UNITS			
Symbol	When You Know	Multiply By	To Find	Symbol	When You Know	Multiply By	To Find
LENGTH				LENGTH			
in.	inches	25.40000	millimetres	mm	millimetres	0.03937	inches
ft	feet	0.30480	metres	m	metres	3.28084	feet
yd	yards	0.91440	metres	m	metres	1.09361	yds
mi	miles	1.60934	kilometres	km	kilometres	0.62137	mi
AREA				AREA			
in. ²	square inches	645.16000	millimetres squared	mm ²	millimetres squared	0.00155	square inches
ft ²	square feet	0.09290	metres squared	m ²	metres squared	10.76392	square feet
yd ²	square yards	0.83613	metres squared	m ²	metres squared	1.19599	square yards
ac	acres	0.40469	hectares	ha	hectares	2.47103	acres
mi ²	square miles	2.58999	kilometres squared	km ²	kilometres squared	0.38610	square miles
VOLUME				VOLUME			
fl oz	fluid ounces	29.57353	millilitres	ml	millilitres	0.03381	fluid ounces
gal.	gallons	3.78541	litres	l	litres	0.26417	gallons
ft ³	cubic feet	0.02832	metres cubed	m ³	metres cubed	35.31448	cubic feet
yd ³	cubic yards	0.76455	metres cubed	m ³	metres cubed	1.30795	cubic yards
MASS				MASS			
oz	ounces	28.34952	grams	g	grams	0.03527	ounces
lb	pounds	0.45359	kilograms	kg	kilograms	2.20462	pounds
T	short tons (2000 lb)	0.90718	megagrams	Mg	megagrams	1.10231	short tons (2000 lb)
FORCE AND PRESSURE				FORCE			
lbf	pound-force	4.44822	newtons	N	newtons	0.22481	pound-force
psi	pound-force per square inch	6.89476	kilopascal	kPa	kilopascal	0.14504	pound-force per square inch
ILLUMINATION				ILLUMINATION			
fc	foot-candles	10.76426	lux	lx	lux	0.09290	foot-candles
fl	foot-Lamberts	3.42583	candela/m ²	cd/m ²	candela/m ²	0.29190	foot-Lamberts
TEMPERATURE (exact)				TEMPERATURE (exact)			
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

Rev 12/93

TABLE OF CONTENTS

METRIC CONVERSION CHART.....	i
EXECUTIVE SUMMARY	iii
INTRODUCTION.....	1
EXPERIMENT DESIGN.....	2
MEMBRANE CONSTRUCTION.....	3
MEMBRANE MATERIALS.....	7
OWNER/CONTRACTOR INFORMATION	8
PAVEMENT MOISTURE SENSORS	10
PAVEMENT STRUCTURE.....	12
PAVEMENT MOISTURE DATA.....	14
CONCLUSIONS	20
REFERENCES.....	21

*PROTECTED UNDER INTERNATIONAL COPYRIGHT
ALL RIGHTS RESERVED
NATIONAL TECHNICAL INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE*

Reproduced from
best available copy.



RUBBERIZED ASPHALT MEMBRANE

EXECUTIVE SUMMARY

This document reports findings of a study involving the use of scrap tire chips in an asphaltic membrane. The research project was designed with two objectives in mind. First, to investigate the effectiveness of an asphaltic membrane on top of a subgrade for maintaining moisture equilibrium in subgrade, and second, to study the potential use of scrap tire chips in asphaltic membranes. The effectiveness of the membrane as a moisture barrier needs to be evaluated over a long period of time (i.e. several years). However, the method proved to be a feasible alternative for recycling waste tires in pavements. It is hoped that this study will contribute to various efforts in the area of cost effective and sound utilization of waste materials in construction.

INTRODUCTION

The use of an asphalt membrane interlayer in pavements is not a new concept. Researchers and practitioners have had an ample amount of experience with pavement membranes for stress relieving purposes (Kidd 1990, Moody 1994). Such a membrane is referred to as stress absorbing membrane interlayer (SAMI). The SAMI is often sandwiched between an old pavement surface and a new overlay (NCHRP 1989, Lorenz 1987).

The membrane interlayer in this project was designed to serve two diverse purposes. First, to investigate the effectiveness of an asphaltic membrane on top of a subgrade for maintaining moisture equilibrium in the subgrade, and second, to study the potential use of scrap tire chips in asphaltic membranes. Various uses of scrap tires in hot mix asphalt (HMA) have been explored in the past several decades, as summarized by FHWA (Heitzman 1992). In this study, it is hypothesized that the membrane interlayer applications with tire chips in pavements may not have as many potential environmental side effects as there are associated with the HMA-crumb rubber applications. Such problems may include: potential emissions problems during production of HMA, and issues related to re-recycling.

The initial concept of a membrane on top of the subgrade was presented in Kentucky by Mr. Ellis Williams (Williams 1989) as a means for maintaining moisture equilibrium in the subgrade. This theory continues as far as stating that marginal subgrades with potential for shrinkage and swelling due to moisture fluctuation may be "stabilized" through a moisture stabilization process.

Plastic clays are susceptible to expansion and shrinkage due to changes in their moisture content. Chemical modification (stabilization) of subgrade soils in highway construction is often a standard procedure for dealing with expansive clays. On the other hand, the membrane concept which has been put forward involves the use of a membrane to partially isolate the subgrade. This partial isolation of subgrade is hoped to provide moisture equilibrium, a condition which would theoretically render chemical stabilization unnecessary. It must be mentioned that chemical stabilization has the unique long-term advantage of pozzolonic cementing and subgrade strengthening properties, which are highly desirable. However, the advantage of applying membrane is in its expediency and ease of application.

EXPERIMENT DESIGN

An experiment was designed to evaluate the construction and performance of the membrane in this study. The following presents a summary of parameters that have been included in the experiment.

Table 1. Summary of Experiment Design Parameters.

	Membrane	Non-Membrane
Base Layer Gage	Locations: 1,2&3	Locations: 1,2&3
Subgrade Gage	Locations: 1,2&3	Locations: 1,2&3

Control Section

In order to have a statistically valid comparison, a control section was included in the project (i.e. a section of the project was constructed without a membrane).

Replication

Moisture sensors were installed at three locations along the length of the project. This level of replication was maintained for both the control and the membrane treated sections.

Moisture Sensor Placement

The effectiveness of the asphalt membrane as a moisture barrier must be evaluated on a long-term basis with moisture sensors. These sensors were placed under and over the membrane within the pavement structure at three replicate locations (that is, a total of six sensors). In order to allow for valid statistical comparisons, six sensors were installed in the control section as well. These were in an approximate symmetry to the section with the membrane along the opposing traffic lanes.

Minimizing Bias

Care was taken to select a relatively flat terrain section of the roadway for conducting comparisons. Also, visual inspections were made to ensure uniformity of geological features as well as absence of any major surface and/or underground water sources that may introduce bias into the pavement moisture profile.

Randomization

The selection of roadway approach for application of the membrane, as well as the selection of moisture sensors and their installation was conducted in accordance to a random process. This was done in order to ensure randomness of errors and minimization of bias.

MEMBRANE CONSTRUCTION

Project Location and Layout

The membrane project that is being discussed in this paper took place on State Route KY-9, approximately 3.2 kilometers (2 miles) west of Maysville, Kentucky -- or approximately 43 kilometers (55 miles) southeast of Cincinnati. Construction of the new pavement on this project was part of an expansion from two lanes to four lanes; each traffic approach was approximately 1.8 kilometers (1.1 miles) in length. The KY-9 state route is a major rural arterial along the Ohio River that connects the following cities: Cincinnati, Covington, Alexandria, and Ashland; this road is also known as the "AA-Highway" (connecting Ashland to Alexandria). A schematic layout of the project is given in Figure 1. Construction activities on this project were documented on photographs and videotapes, which will be maintained on file at the Kentucky Transportation Center.

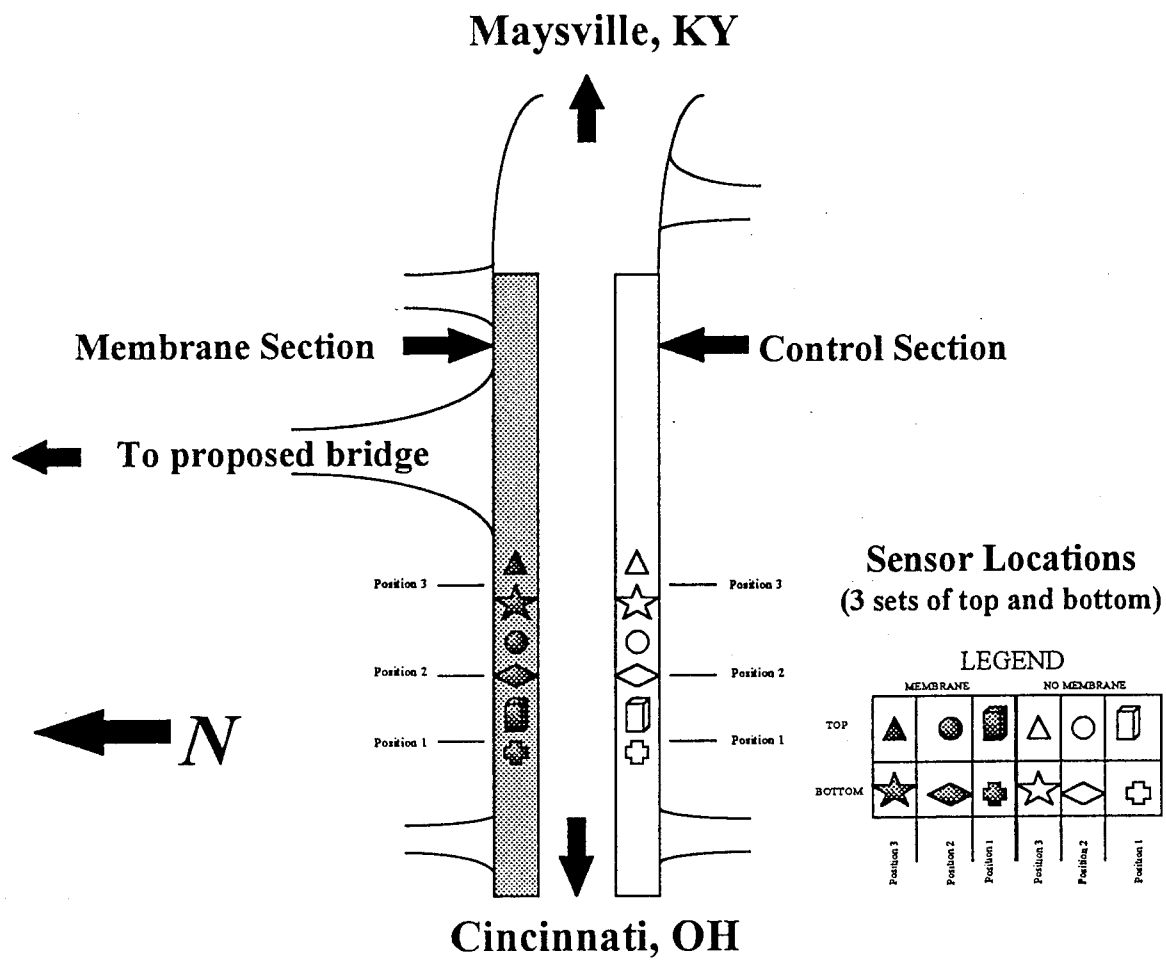


Figure 1. Project Layout.

Construction Planning

The membrane design called for a rich spray application of asphalt cement directly on top of the subgrade. The design also included a stone coverage as well as scrap tire chips. At the first glance, the basic construction issues surrounding this project appeared to be similar to seal coat construction. These fundamental construction issues were outlined by several researchers (Benson and Gallaway 1953), and (Kearby 1953). However, this project posed unique issues that are presented in the following paragraphs.

Conceptually, the design of the membrane in this project intended for the mixture of tire chips and the asphalt to form a good contact and form a matrix. The entire membrane was to be covered with a conventional flexible pavement, details of which are presented in the section dealing with the pavement structure.

The following sections describe the process by which the constructibility issues were examined.

Constructibility Issues

Initially, it was envisioned that the tire chips may be mixed with the cover stone to provide an aggregate blend (rocks and tire chips) for covering the freshly sprayed hot asphalt. The question was raised during the construction phase as to the potential for serious segregation of rocks and tire chips. This was expected to be a problem due to a significant difference in the specific gravity of these two very different materials. As a result, it was decided to have the cover stone and the tire chips applied separately.

Once it was decided to have separate applications of cover stone and tire chips, the next issue was the order of application. At the same time, in order to ensure the integrity of the membrane, it was important for the tire chips and hot liquid asphalt spray to form a good bond and develop a matrix. This requirement made it necessary for the tire chips and the asphalt spray to come into contact first. The final component of this membrane was an application of cover stone.

Membrane Test Strips - First Trial

A test strip of approximately 91.2 meters (300 feet) was constructed to verify various construction parameters. The test strip included a rich asphalt cement spray application at 3.6 liters per square meter (0.8 gallon per square yard) directly on top of the compacted subgrade. This application was followed by an application of 8.1 kilograms per square meter (15 pounds per square yard) of tire chips with a spreader unit in a manner similar to a chip seal application.

The application of tire chips over a freshly applied rich asphalt layer posed a serious construction difficulty. The problem occurred when the hot liquid asphalt migrated upward through the rubber cover chips under pressure from the spreader's tires. This brought the hot liquid asphalt into direct contact with the spreader's tires and caused a "pick-up" problem and ultimately tearing the membrane. It became obvious that the application of tire chips directly on top of the hot asphalt layer was not a feasible option.

Membrane Test Strips - Second Trial

A second test strip, approximately 91.2 meters (300 feet), was constructed with the application of tire chips first, at the rate of 8.1 kilograms per square meter (15 pounds per square yard) directly on top of the subgrade. There was some concern that the prevailing wind conditions at the construction site may disturb this layer of chips on top of the subgrade; however, this did not prove to be a problem.

The rubber chips were then covered with an asphalt spray at the rate of 3.6 liters per square meter (0.8 gallon per square yard). This proved to be a successful application. The asphalt and tire chips had an opportunity to come into direct contact with each other and form a matrix. Because of affinity of rubber particles for asphalt, some "reaction" was expected to occur on the surface of the tire chips. This membrane was later covered with the cover stone. Total thickness of the finished membrane on this project was approximately 1.25 cm (0.5 in). This is the application that was chosen for the entire project. Finally, the rest of the pavement structure was placed on top of the membrane.

MEMBRANE MATERIALS

Modified Asphalt Cement

The type of asphalt cement used in the membrane was a polymer modified AC-20 (Kentucky classification: PMAC-1C). The polymer modifier was a styrene-butadiene-styrene (SBS) at the rate of 3% by weight of the asphalt cement. Terry Industries from Ohio supplied the liquid modified asphalt as well as the placement of the tire chips and spraying of the asphalt.

Tire Rubber Chips

The recycled tires on this project were shredded in such a fashion that produced a gradation distribution; this distribution is presented in Figure 2. The tire chips were free of steel or any other deleterious materials. The chips appeared to develop a "surface reaction" with the hot asphalt spray without any difficulty, which promoted formation of a matrix upon receiving the asphalt spray.

Membrane Cover Stone

The run-of-mine (ROM) aggregate material was used to provide a final surface for the membrane prior to other layers of pavement being constructed. The cover stone did an adequate job of binding to the matrix of tire chips and asphalt cement. The gradation of ROM is given in Figure 2.

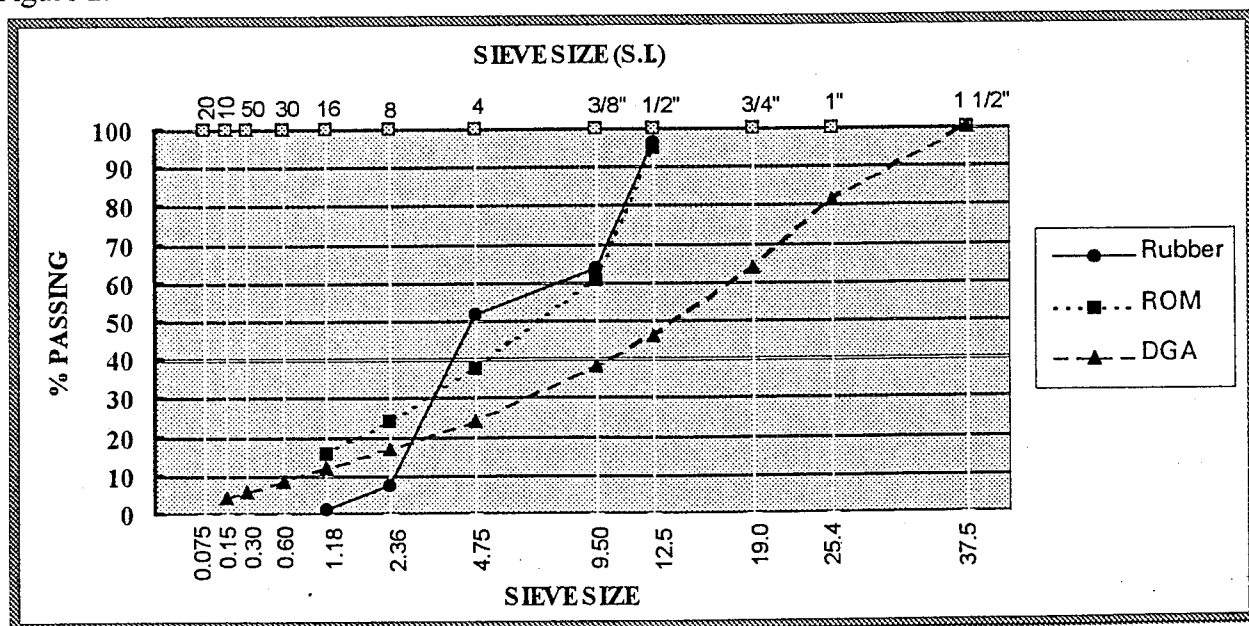


Figure 2. Gradation Chart.

Cost of Membrane

The cost of this membrane with rubber chips was \$2.54/m² (\$3.05/yd²). By comparison, the conventional membrane without the rubber chips would cost \$1.34/m² (\$1.64/yd²). The additional cost of the membrane which included rubber chips was due to the addition of rubber. Also, the cost of lime stabilization of the subgrade on this project would have been approximately .50/m² (\$3.00/yd²). Obviously, these cost figures may vary depending upon the size of the project, location, and other factors. Finally, the tire utilization rate on this project was approximately 1,760 tires per lane mile.

OWNER/CONTRACTOR INFORMATION

The following is a summary of owner/contractor key contact persons and their respective roles on the construction project.

Project Management

Kentucky Transportation Cabinet
District-9 Office
Flemingsburg, KY

Contacts: (606) 845-2551
Pete Shaffer
Jim Rummage
Paul Ford (Project Engineer)
Stan Martin (Resident Engineer)

Prime Contractor

Elmo Greer & Sons, Inc.
P.O. Box 730
London, KY 40743

Contacts: (606) 843-6136
Wayne Simmons (project manager)

Job Description:

Removed existing shoulders, widened cuts, and worked the subgrade to meet the required elevations.

Subcontractors:

1. **Volunteer Highway Supply Company**
7603 Maynardville Highway
Knoxville, TN 37938

Contacts: (615) 922-7473

Job Description:

Placed striping on completed project

2. **H.G. Mays Corporation**
P.O. Box 797
Frankfort, KY 40602

Contacts: (502) 875-1282

Tony McGlone
Gene Shelton

Job Description:

Transported and placed all subbase aggregate and rubber chips. Produced, transported, and placed all asphalt mixes. Subcontracted the job of supplying and placing the asphalt membrane to Terry Industries.

3. **Meeks Electrical, Inc.**
700 Northview
Paducah, KY 42001

Contacts: (502) 444-7779

Job Description:

Installation of traffic signals

4. **Anpat, Inc.**
918 South Mayo Trail
Pikeville, KY 41501

Contacts: (606) 432-3166

Job Description:

Placement of guardrail and seeding.

5. **Terry Industries**
8600 Berk Blvd.
Hamilton, OH 45015

Contacts: (513) 874-6192
Todd Terry
Mark Terry

Job Description:

Placed the asphalt membrane on top of the subgrade with and without the rubber chips for the experimental and control sections, respectively.

PAVEMENT MOISTURE SENSORS

In order to determine the effectiveness of the rubberized asphalt membrane on top of the subgrade, it was decided to install moisture sensors in the subgrade and subbase of the pavement. Details on installation of sensors are given under the section describing the experiment design. These sensors detect the amount of soil moisture based upon soil electrical resistivity. Prior to field installation, in order to ensure accurate characterization of soil moisture content, a detailed calibration of sensors was conducted in the laboratory at the University of Kentucky. Representative soil specimens from the field project were used in this calibration effort. It was discovered that these moisture gages are subjected to a rigorous quality control process by the manufacturer, and that they follow a common pattern for soil moisture content versus resistivity for a given soil. A summary of calibration points and associated regressions are given in Figure 3. Long-term collection of field data on pavement moisture profile needs to be conducted. The construction of this project was completed in mid July of 1995.

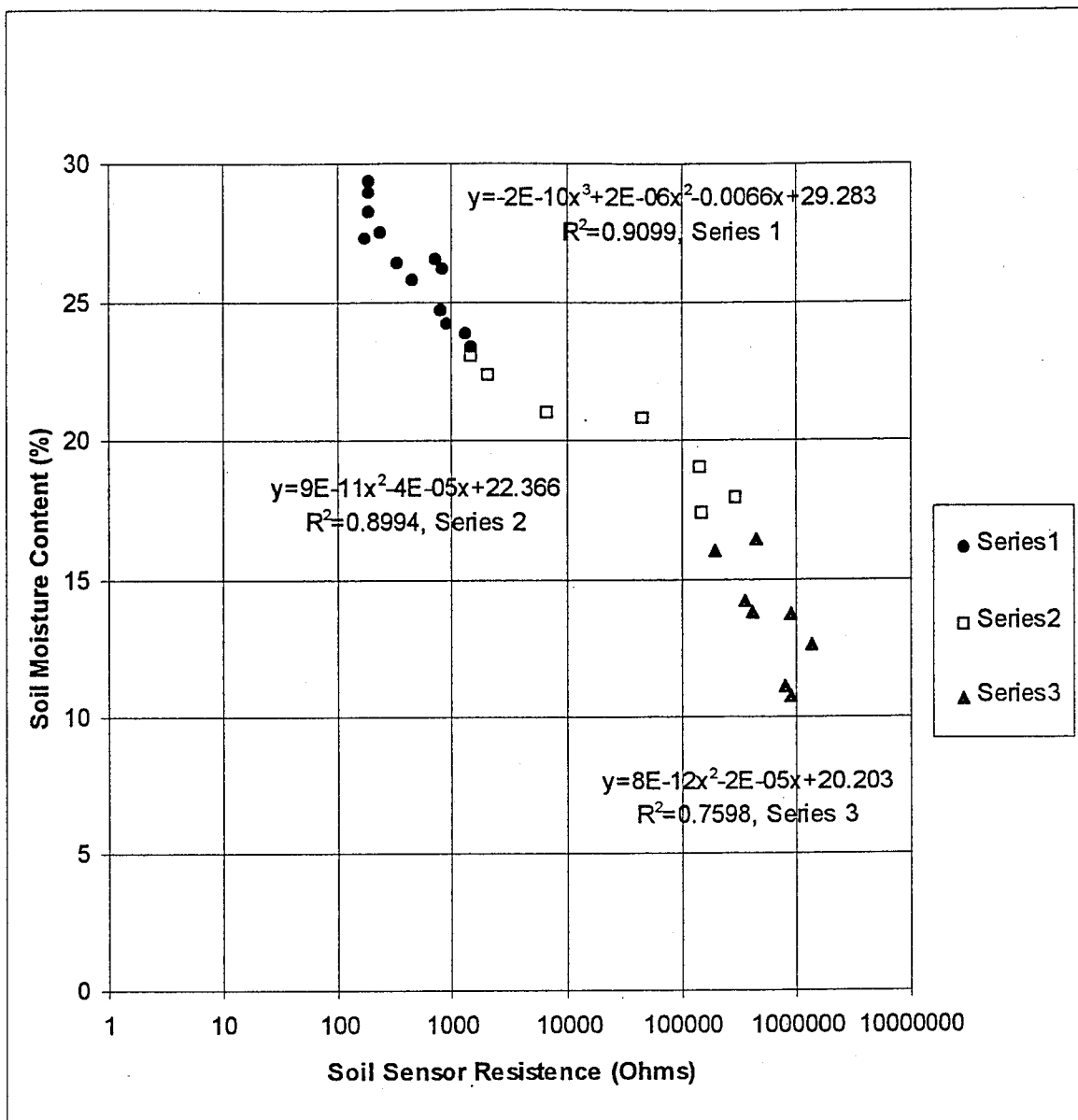


Figure 3. Moisture Gage Calibration Chart.

PAVEMENT STRUCTURE

Pavement Subgrade

The subgrade was a clayey material mixed with some shale. This mixture of clay and shale exhibited a CBR of approximately. The Kentucky procedure for "Slake Durability" resulted in a durability index of above 95% for the shale component of the subgrade. In summary, the subgrade was not a particularly strong roadbed material, and it was hypothesized that perhaps it could benefit from chemical stabilization. It was decided to explore the membrane effectiveness as a subgrade moisture stabilizer on this project. To ensure statistically valid comparisons, the eastbound lanes served as the control section (i.e. without membrane), and westbound lanes served as the treatment section (i.e. with membrane).

Pavement Subbase

The pavement subbase consisted of subgrade was later covered with 38.1 cm (15 in) of a dense graded aggregate (DGA), gradation of which is presented in Figure 2. Generally, DGA bases and subbases are not known to be free draining because of their relatively high fine content. However, in this project we were fortunate to have a DGA subbase with a relatively low fine content.

Pavement Base

Kentucky Class-I hot mix base material was placed in several lifts: two lifts of 6.98 cm (2.75 in), and a single lift of 6.4 cm (2.5 in); hence, the total asphalt base thickness was 20.3 cm (8 in). This pavement base was later covered with a 3.81-cm (1.5-in) layer of Kentucky Class-I as a binder course prior to application of the surface mix.

Pavement Surface

Finally, the pavement was finished with 3.17 cm (1.25 in) of Kentucky Class-I surface; this is a conventional dense HMA surface mix in Kentucky. A schematic diagram of the pavement structure is given in Figure 4.

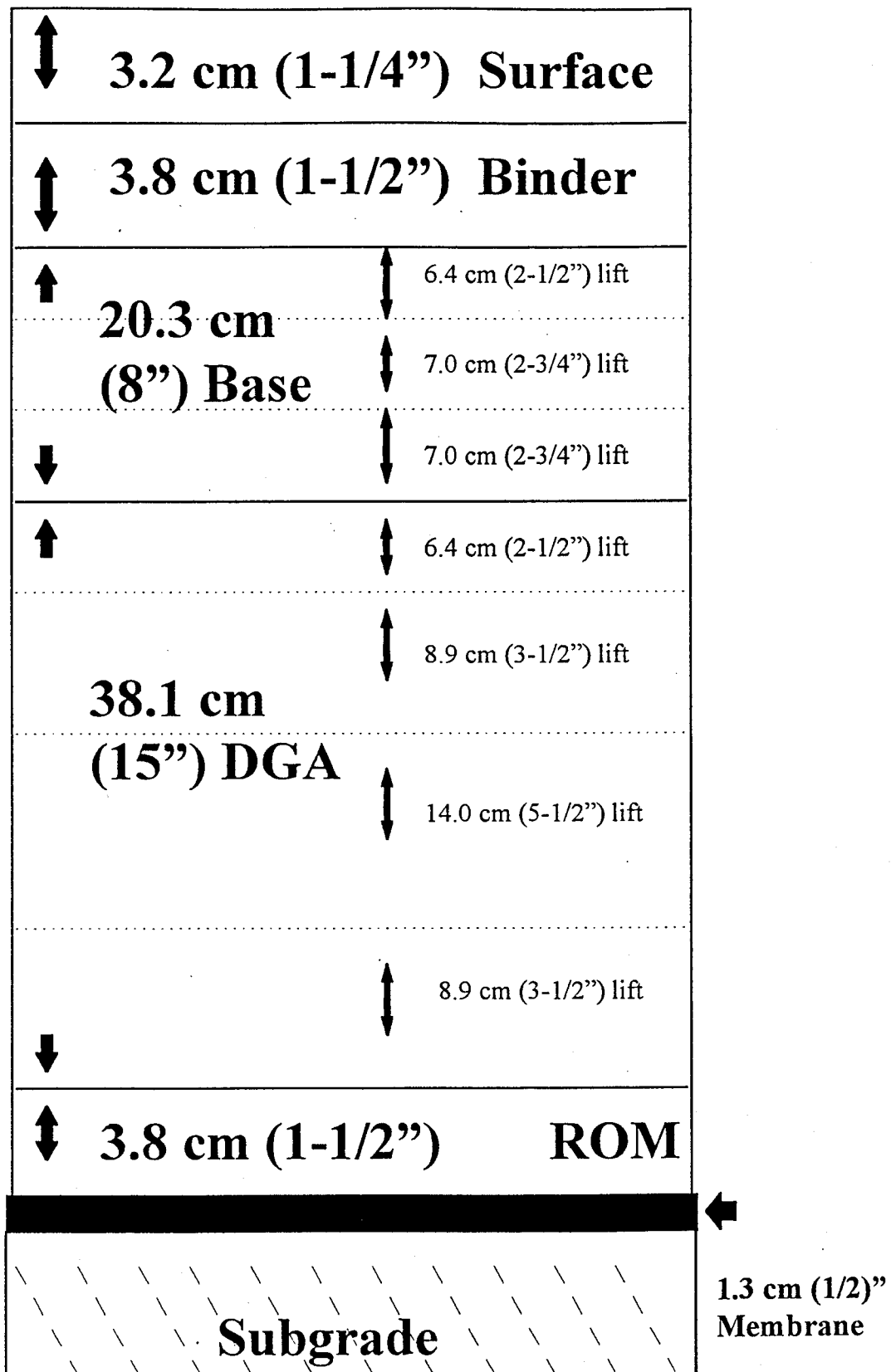


Figure 4. Pavement Structure.

PAVEMENT MOISTURE DATA

Monthly readings of moisture sensor gages were obtained since the completion of the project (July 1995). These data are presented in Tables 2 and 3, and their graphical representations are given in Figures 5 and 6.

By and large, pavement moisture profiles on this project reflected an unstable trend with a gradual tendency to converge toward a more stable trend. This is to be expected due to initial disturbance of equilibrium conditions of local hydro-geological features at the construction site. Eventually, water flow through the pavement structure is expected to follow a rather stable trend with changes reflecting seasonal and/or climatic variations. However, the hypothesis for moisture equilibrium in a subgrade covered with a rubberized asphalt membrane cannot be supported at this time. In summary, long-term pavement moisture data over a period of several years needs to be collected in order to establish the effectiveness of such a membrane.

Date	Eastbound--Control Section					Westbound--Membrane Section				
	Loc.	Temp. (C)	Resistance	Calib. Fact.	% Moisture	Loc.	Temp. (C)	Resistance	Calib. Fact.	% Moisture
			ohm					ohm		
Jul-95	1t	33.2	445	0.0601	26.76	1t	29.6	765	0.0333	25.49
	2t	33.6	60	0.4816	28.89	2t	30.8	335	0.0815	27.30
	3t	33.2	435	0.0616	26.81	3t	29.2	200	0.1402	28.04
	1b	29.9	780	0.0326	25.45	1b	27.7	750	0.0341	25.54
	2b	30.2	950	0.0263	24.99	2b	26.4	17150	0.0013	21.71
	3b	30.1	755	0.0338	25.53	3b	25.5	370	0.0733	27.12
Sep-95	1t	31.8	210	0.1333	27.99	1t	33.8	560	0.0469	26.25
	2t	34.2	70	0.4119	28.83	2t	34	510	0.0519	26.46
	3t	34.2	200	0.1402	28.04	3t	33.8	1270	0.0193	24.54
	1b	32.3	580	0.0451	26.17	1b	31.8	870	0.0290	25.19
	2b	32.3	810	0.0313	25.36	2b	32.2	2400	0.0093	22.27
	3b	32.2	610	0.0427	26.05	3b	30.6	1190	0.0207	24.60
Oct-95	1t	14.0	80.0	0.3596	28.77	1t	22.8	180.0	0.1564	28.16
	2t	21.9	30.0	0.9696	29.09	2t	22.8	100.0	0.2864	28.64
	3t	23.0	80.0	0.3596	28.77	3t	23.0	120.0	0.2377	28.52
	1b	22.5	690.0	0.0373	25.75	1b	23.0	490.0	0.0542	26.55
	2b	22.2	820.0	0.0309	25.33	2b	17.8	2000.0	0.0111	22.29
	3b	19.0	510.0	0.0519	26.46	3b	22.0	1475.0	0.0166	24.54
Nov-95	1t	-1.5	60	0.4816	28.89	1t	7.4	115	0.2483	28.55
	2t	5.1	30	0.9696	29.09	2t	7.05	85	0.3381	28.74
	3t	9	60	0.4816	28.89	3t	8.4	50	0.5792	28.96
	1b	8.5	965	0.0259	24.96	1b	9.7	305	0.0900	27.46
	2b	8.45	840	0.0301	25.27	2b	0.7	525	0.0503	26.40
	3b	2.15	975	0.0256	24.93	3b	8.95	1940	0.0115	22.29
Jan-96	1t	-7.5	60	0.4816	28.89	1t	2.2	90	0.3189	28.71
	2t	-0.4	20	1.4576	29.15	2t	2.2	90	0.3189	28.71
	3t	2	60	0.4816	28.89	3t	2.8	50	0.5792	28.96
	1b	2.2	1120	0.0220	24.68	1b	4	300	0.0916	27.49
	2b	2.5	740	0.0346	25.58	2b	-5	300	0.0916	27.49
	3b	-5.5	1100	0.0225	24.71	3b	3.2	2000	0.0111	22.29
Feb-96	1t	-6	40	0.7256	29.02	1t	2	400	0.0674	26.98
	2t	0	40	0.7256	29.02	2t	2	60	0.4816	28.89
	3t	2.5	60	0.4816	28.89	3t	3	150	0.1889	28.34
	1b	1.9	1150	0.0214	24.64	1b	2	270	0.1024	27.65
	2b	1.8	750	0.0341	25.54	2b	-7.8	110	0.2598	28.58
	3b	-9	1100	0.0225	24.71	3b	1.8	1800	0.0124	22.29
Mar-96	1t	1	50	0.5792	28.96	1t	10	300	0.0916	27.49
	2t	7	20	1.4576	29.15	2t	10	100	0.2864	28.64
	3t	10	200	0.1402	28.04	3t	10	200	0.1402	28.04
	1b	9	800	0.0317	25.39	1b	10	300	0.0916	27.49
	2b	-10	400.00	0.0674	26.98	2b	0	200	0.1402	28.04
	3b	-2	600	0.0435	26.09	3b	8	800	0.0317	25.39

Table 2. Pavement Moisture Data.

	Eastbound--Control Section				%	Westbound--Membrane Section				%
Date	Loc.	Temp. (C)	Resistance	Calib. Fact	Moisture	Loc.	Temp. (C)	Resistance	Calib. Fact	Moisture
			ohm					ohm		
Apr-96	1t	1	50	0.5792	28.96	1t	10	300	0.0916	27.49
	2t	7	20	1.4576	29.15	2t	10	100	0.2864	28.64
	3t	10	200	0.1402	28.04	3t	10	200	0.1402	28.04
	1b	9	800	0.0317	25.39	1b	10	300	0.0916	27.49
	2b	-10	400.00	0.0674	26.98	2b	0	200	0.1402	28.04
	3b	-2	600	0.0435	26.09	3b	8	800	0.0317	25.39
May-96	1t	6	20	1.4576	29.15	1t	14	290	0.0950	27.54
	2t	11	10	2.9217	29.22	2t	15	100	0.2864	28.64
	3t	16	10	2.9217	29.22	3t	15	200	0.1402	28.04
	1b	14	780	0.0326	25.45	1b	16	300	0.0916	27.49
	2b	13	400	0.0674	26.98	2b	4	250	0.1110	27.76
	3b	1	800	0.0317	25.39	3b	13	800	0.0317	25.39
Jun-96	1t	8	10	2.9217	29.22	1t	20	290	0.0950	27.54
	2t	14	10	2.9217	29.22	2t	19	100	0.2864	28.64
	3t	20	20	1.4576	29.15	3t	19	180	0.1564	28.16
	1b	18	700	0.0367	25.71	1b	20	300	0.0916	27.49
	2b	17	20	1.4576	29.15	2b	7	300	0.0916	27.49
	3b	2	500	0.0530	26.51	3b	16	800	0.0317	25.39
Jul-96	1t	10	10	2.9217	29.22	1t	20	290	0.0950	27.54
	2t	16	10	2.9217	29.22	2t	19	100	0.2864	28.64
	3t	25	20	1.4576	29.15	3t	19	180	0.1564	28.16
	1b	20	700	0.0367	25.71	1b	20	300	0.0916	27.49
	2b	19	20	1.4576	29.15	2b	7	300	0.0916	27.49
	3b	4	500	0.0530	26.51	3b	16	800	0.0317	25.39

Table 2 (Continued). Pavement Moisture Data.

Moisture Content (%) Westbound -- Leaving Maysville						
<u>Date</u>	<u>1top</u>	<u>2top</u>	<u>3top</u>	<u>1bott.</u>	<u>2bott.</u>	<u>3bott.</u>
Jul-95	25.49	27.30	28.04	25.54	21.71	27.12
Sep-95	26.25	26.46	24.54	25.19	22.27	24.60
Oct-95	28.16	28.64	28.52	26.55	22.29	22.29
Nov-95	28.55	28.74	28.96	27.46	26.40	22.29
Jan-96	28.71	28.71	28.96	27.49	27.49	22.29
Feb-96	26.98	28.89	28.34	27.65	28.58	22.29
Mar-96	27.49	28.64	28.04	27.49	28.04	25.39
Apr-96	27.49	28.64	28.04	27.49	28.04	25.39
May-96	27.54	28.64	28.04	27.49	27.76	25.39
Jun-96	27.54	28.64	28.16	27.49	27.49	25.39
Jul-96	27.54	28.64	28.16	27.49	27.49	25.39
Moisture Content (%) Eastbound -- Going to Maysville						
<u>Date</u>	<u>1top</u>	<u>2top</u>	<u>3top</u>	<u>1bott.</u>	<u>2bott.</u>	<u>3bott.</u>
Jul-95	26.76	28.89	26.81	25.45	24.99	25.53
Sep-95	27.99	28.83	28.04	26.17	25.36	26.05
Oct-95	28.77	29.09	28.77	25.75	25.33	26.46
Nov-95	28.89	29.09	28.89	24.96	25.27	24.93
Jan-96	28.89	29.15	28.89	24.68	25.58	24.71
Feb-96	29.02	29.02	28.89	24.64	25.54	24.71
Mar-96	28.96	29.15	28.04	25.39	26.98	26.09
Apr-96	28.96	29.15	28.04	25.39	26.98	26.09
May-96	29.15	29.22	29.22	25.45	26.98	25.39
Jun-96	29.22	29.22	29.15	25.71	29.15	26.51
Jul-96	29.22	29.22	29.15	25.71	29.15	26.51

Table 3. Summary Pavement Moisture Data.

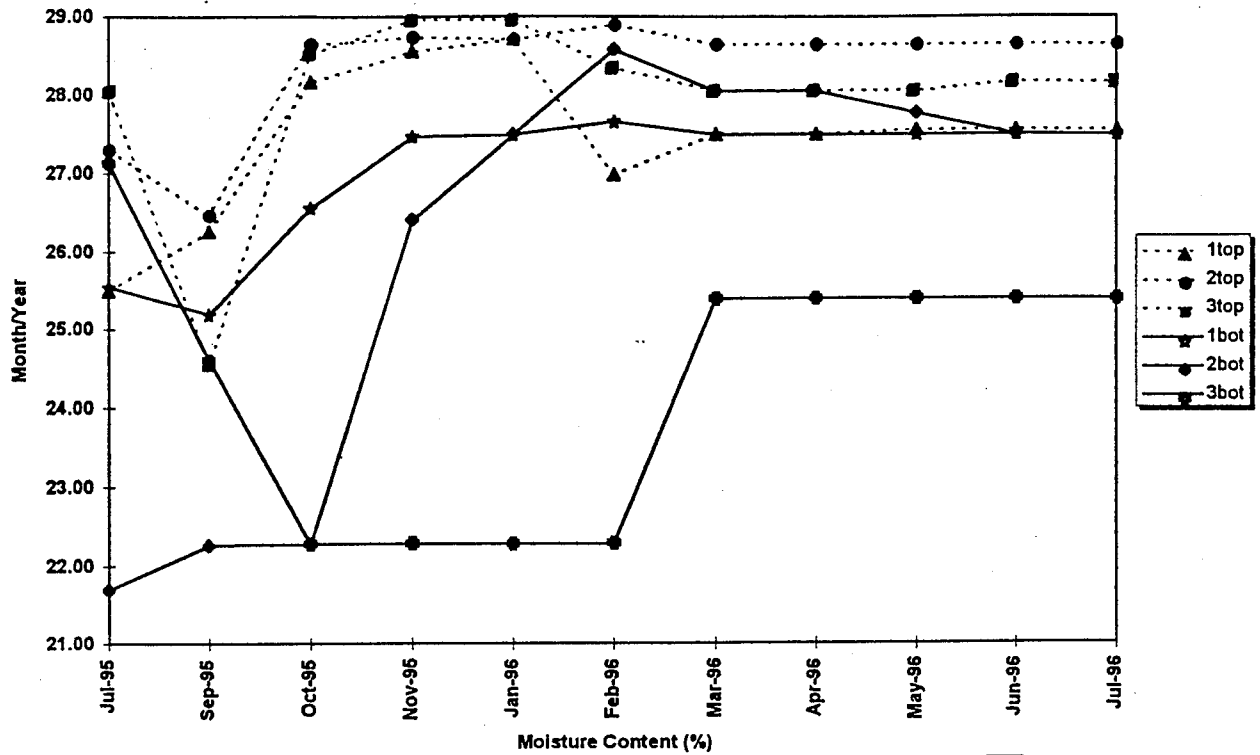


Figure 5. Pavement Moisture Data (Westbound, with Membrane).

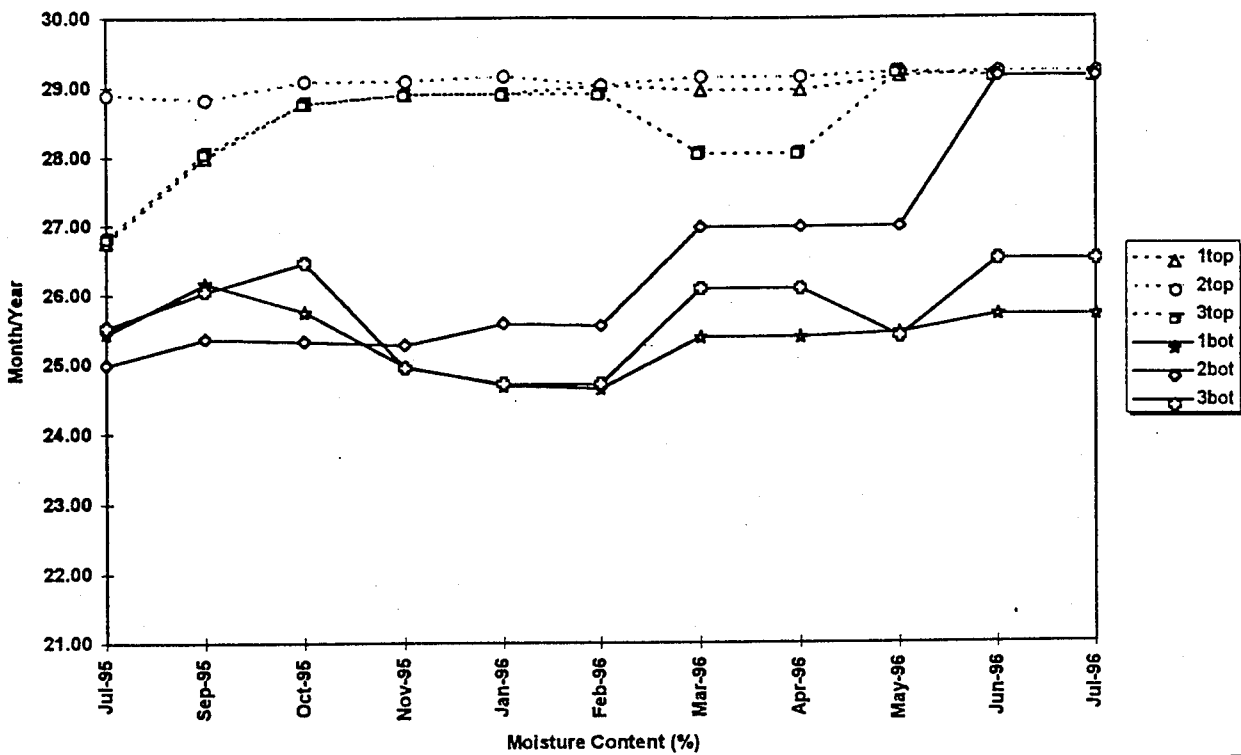


Figure 6. Pavement Moisture Data (Eastbound, without Membrane).

CONCLUSIONS

1. This project demonstrated that scrap tires may be recycled effectively in the form of rubber chips in asphalt interlayer applications.
2. Proper construction techniques for the placement of rubber chips in interlayer applications are very important. Kentucky's experience was presented in this report.
3. The process presented in this report has the potential of recycling waste tires at an approximate rate of 1,760 tires per lane mile.
4. Preliminary pavement moisture profile data are inconclusive. At this time, it is not possible to support the effectiveness of subgrade membrane in allowing the subgrade to achieve moisture equilibrium. Obviously, long-term data are needed in order to effectively characterize the influence of this asphaltic membrane on moisture profile within the pavement structure.
5. Long-term performance of the pavement on this project needs to be monitored for evaluating the effects of pavement moisture profile on the overall pavement performance.

REFERENCES

- F.J. Benson, and B.M. Gallaway. "Retention of Cover Stone by Asphalt Surface Treatments". Bulletin 133, Texas Engineering Experiment Station, Texas A&M University, September 1953.
- M.A. Heitzman. "State of the Practice - Design and Construction of Asphalt Paving Materials with Crumb Rubber Modifier". Publication No. FHWA-SA-92-022, Federal Highway Administration, Washington, DC, 1992.
- V.M. Lorenz. "New Mexico Study of Interlayers Used in Reflective Cracking Control". In *Transportation Research Record 1117*, TRB, National Research Council, Washington, DC, 1987.
- S.Q. Kidd. "Paving Fabric and Asphalt Stress Absorbing Membrane Interlayer (SAMI). Report MSMD-RD-90-67-6, Mississippi State Highway Department. August 1990.
- J.P. Kearby. "Tests and Theories on Penetration Surfaces". Highway Research Board Proceedings, Volume 32, 1953.
- N.W. McLeod. "A General Method of Design for Seal Coats and Surfaces Treatments". Proceedings of Association of Asphalt Paving Technologists, Volume 38, 1969.
- E.D. Moody. "Field Investigations of Selected Strategies to Reduce Reflective Cracking in Asphalt Concrete Overlays Constructed over Existing Jointed Concrete Pavements". In *Transportation Research Record 1449*, TRB, National Research Council, Washington, DC, 1994.
- NCHRP Synthesis of Highway Practice 144: Breaking/Cracking and Sealing Pavements*. TRB, National Research Council, Washington, DC, March 1989.
- E.G. Williams. "Moisture Profiles in Pavements". A Distinguished Alumni Lecture, Chi Epsilon - UK Chapter, Fall Semester 1989, Department of Civil Engineering, University of Kentucky, Lexington, Kentucky.

